FULL CONTENTS

[Claim(s)]
[Claim 1]Steam generated by operation of said fuel cell in a fuel cell system, comprising, Or a fuel cell system, wherein reforming of hydrocarbon raw materials is performed using steam or oxygen which provided a terminal area which connects said fuel cell and a reforming section so that sending to said reforming section might be possible in at least one side of unreacted oxygen, and was sent into a reforming section from a fuel cell via a terminal area.
A reforming section which reforms hydrocarbon raw materials and generates hydrogen.
A fuel cell which generates electricity by supplying said hydrogen and oxygen as fuel.

[Claim 2]The fuel cell system according to claim 1 equipping said terminal area with a control part which controls quantity which sends steam or oxygen into said reforming section, and controlling a reforming reaction of hydrocarbon raw materials in a reforming section.
[Claim 3]It has an oxygen utilization factor regulation means which adjusts an oxygen utilization factor in said fuel cell, The fuel cell system according to claim 1 or 2, wherein the amount of oxygen which an oxygen utilization factor in a fuel cell is adjusted by an oxygen utilization factor regulation means, and this sends into a reforming section via a terminal area from a fuel cell is adjusted.
[Claim 4]The fuel cell system according to any one of claims 1 to 3, wherein it equips said terminal area with a steam generation part which generates steam using water generated in said fuel cell, it burns unreacted hydrogen discharged from a fuel cell to it in said steam generation part and heating of water is given to it.

[Detailed Description of the Invention]
[0001]

[Field of the Invention]Especially this invention relates to improvement of the fuel cell system provided with the reforming section which generates fuel gas from hydrocarbon raw materials as fuel of a fuel cell about a fuel cell system.
[0002]
[Description of the Prior Art]A fuel cell generally uses oxygen and hydrogen as fuel, and is a device which changes the chemical energy which these fuel has as direct electrical energy without going via thermal energy.
It has characteristics excellent in the environmental aspect, and since high energy efficiency is possible, development is furthered widely as a future energy supply system.

[0003]The general form and principle of a fuel cell arrange a pair of electrodes on both sides of an electrolyte, supply the fuel gas which contains hydrogen in an anode, supply oxygen gas containing oxygen to a cathode, and generate electricity using the electrochemical reaction which occurs with the two electrodes shown below. That is, the chemical reaction of (1) type arises in an anode, and the reaction of (2) arises in a cathode. Therefore, as a reaction of the whole fuel cell, (3) types advance, power generation is performed by hydrogen and oxygen, and subraw [of the water] is carried out simultaneously.
[0004]
H_2-> $2H^+$+$2e^-$ (1)
(1/2) O_2+$2H^+$+$2e^-$ -> H_2O (2)
H_2+(1/2) O_2-> H_2O (3)
When using the above-mentioned fuel cell as a generating set, as fuel gas containing hydrogen, an ideal uses economically natural gas, naphtha, and the alcohols that are methanol further, but. There is no fuel cell which supplies these fuel gas to a battery directly, and can generate it efficiently now, and it has been future development SUBJECT. Therefore, many present fuel cells are equipped with the reforming section which generates fuel gas from hydrocarbon raw materials, and the fuel gas for reforming the above-mentioned natural gas, methanol, etc. and supplying an anode is generated in this reforming section.
[0005]The composition of the conventional fuel cell system provided with the reforming section is shown in drawing 2. The fuel cell system 10 is equipped with the reforming section 12 which reforms hydrocarbon raw materials, such as methane, and generates fuel gas. In this reforming section 12, reforming is performed by various reforming methods, for example, a steam reforming process, a partial oxidation method, etc.
[0006]When steam reforming is performed for methane to below as an example and (4) and partial oxidation are performed, the chemical reaction produced in (5) is shown. Among these, it is necessary to prepare the evaporator 22 for the case where steam reforming is performed,

further at the reforming section 12, to make this evaporator 22 carry out heating evaporation through water, and to supply the reforming section 12 as steam. Although either can also be used for these steam reforming processes and oxidization reforming, performing both sides within the one reforming section 12 simultaneously is also performed.

[0007]

$CH_4+H_2O->3H_2+CO$ (4)

$CH_4+1/2O_2->2H_2+CO$ (5)

The fuel cell system 10 is equipped with the sifting section 14 and CO selective oxidation part 16 for carrying out conversion of CO etc. by which subraw is carried out to CO_2 when generating fuel gas in the reforming section 12. These sifting sections 14 and CO selective oxidation part 16 carry out conversion of CO which CO carries out poisoning of the electrode of the fuel cell 18, and checks operation to CO_2 with little influence to operation of the fuel cell 18. Water is made to act on CO, as shown in (6) types, and H_2 and CO_2 which are fuel gas are made to generate in the sifting section 14. In CO selective oxidation part 16, as shown in (7) types, oxygen is made to act on CO and conversion is carried out to CO_2.

[0008]

$CO+H_2O->H_2+CO_2$ (6)

$CO+1/2O_2->CO_2$ (7)

The fuel gas with which CO was removed in the sifting section 14 and CO selective oxidation part 16 is supplied to the anode of the fuel cell 18, air is supplied to a cathode, power generation is performed within the fuel cell 18, and subraw [of the water] is carried out by the cathode side simultaneously with it. Thus, power generation in a fuel cell is performed in the fuel cell system, reforming hydrocarbon raw materials and generating fuel gas.

[0009]

[Problem to be solved by the invention]Thus, the fuel cell system can generate high energy by hydrogen and oxygen, and, also environmentally, a subproduct is also a suitable power generation system like water, and to miniaturize so that use extensive as a small generating set can be performed is desired. However, the fuel cell system provided with the reforming section etc. which perform reforming of fuel has become large-sized, and the use area is limited.

[0010]Then, this invention is made in light of the above-mentioned problems, and the purpose is to miniaturize the fuel cell system which has a means to generate fuel gas by reforming of materials.

[0011]

[Means for solving problem]To achieve the above objects, in the fuel cell system which has a

fuel cell which generates electricity by the reforming section which this invention reforms hydrocarbon raw materials and generates hydrogen, and said hydrogen and oxygen, The terminal area which connects said fuel cell and a reforming section so that sending to said reforming section may be possible in either [at least] the steam generated by operation of said fuel cell or the oxygen which remains is provided, Reforming of hydrocarbon raw materials is performed using steam or oxygen sent into the reforming section from the fuel cell via the terminal area.

[0012]According to the above-mentioned invention, since the steam generated in the fuel cell was supplied to a reforming section, in order to generate steam required for steam reforming conventionally, it had the evaporator separately, but this evaporator can be omitted and the miniaturization of a system can be attained. It becomes possible by making oxygen supply from a fuel cell for it to become unnecessary to have the conduit which supplies oxygen to a reforming section, and to attain the miniaturization of a system further.

[0013]The fuel cell system of this invention equips said terminal area with the control part which controls the quantity which sends steam or oxygen into said reforming section further, and controls the reforming reaction of the hydrocarbon raw materials in a reforming section.

[0014]According to above-mentioned this invention, the partial-oxidation-reforming reaction of a reforming section is controllable by controlling the quantity which sends in steam by controlling the quantity which can control the steam reforming reaction in a reforming section, and supplies oxygen. Since a steam reforming reaction is an endothermic reaction, when these are made to perform simultaneously within one reforming section to especially these partial-oxidation-reforming reaction being an exothermic reaction, It also becomes possible to control appropriately the temperature in each reaction and by extension, a reforming section by controlling by the water vapor content and the amount of oxygen which supply each reaction.

[0015]The fuel cell system of this invention is provided with the oxygen utilization factor regulation means which adjusts the oxygen utilization factor in said fuel cell further, The oxygen utilization factor in a fuel cell is adjusted by an oxygen utilization factor regulation means, and the amount of oxygen which this sends into a reforming section via a terminal area from a fuel cell is adjusted.

[0016]According to the above-mentioned invention, the oxygen utilization factor in a fuel cell is adjusted, and the amount of oxygen used in a fuel cell and the amount of oxygen supplied to a reforming section can distribute appropriately. Therefore, it becomes possible to make not only operation of a fuel cell but supply of oxygen to the reforming section through a fuel cell perform appropriately the partial oxygen reforming reaction in a reforming section.

[0017]The fuel cell system of this invention is provided with the steam generation part which generates steam to said terminal area using the water discharged from said fuel cell, burns the unreacted hydrogen discharged from a fuel cell in said steam generation part, and heating of

water is performed.

[0018]According to the above-mentioned invention, when just the steam discharged from a fuel cell is not enough as a water vapor content to which steam reforming is made to perform, the water discharged from a fuel cell can be generated in a steam generation part, and it can also supplement with an insufficiency with it. In this case, although it will be necessary to have a steam generation machine further, since this steam generation machine is what generates steam of an insufficiency, a large-sized device like an evaporator like before is not needed. In particular, in this invention, this steam generation machine can also be miniaturized by burning unreacted hydrogen of a fuel cell by oxygen as fuel for generating the steam running short, and making the energy of steam generation.

[0019]

[Mode for carrying out the invention]Hereafter, the suitable embodiment of this invention is described using Drawings. The entire configuration of the fuel cell system 30 concerning this embodiment is shown in drawing 1.

[0020]In order to remove CO from the reforming section 32 which reforms hydrocarbon raw materials and generates fuel gas, and the fuel gas generated by this reforming section 32, it has the sifting section 33 and CO selective oxidation part 35, and this fuel cell system 30 operates the fuel cell 34 using the fuel gas (hydrogen) which passed through these. In particular, in this fuel cell system 30, it is directly connected to the fuel cell 34 via the connecting pipe 36, and the composition which makes the reforming section 32 circulate through the steam by which subraw is carried out by the cathode side of the fuel cell 34, and unreacted oxygen is adopted.

[0021]namely, the thing which the fuel cell system 30 of this embodiment returns the water as steam by which subraw is carried out by the fuel cell 34 to the reforming section 32, and the steam reforming of materials is made to perform, and you send in unreacted oxygen of the fuel cell 34, and is made to perform partial oxidation reforming -- it is carrying out. Hereafter, each composition is explained in detail.

[0022]As the fuel cell 34 employable as this fuel cell system 30, when generating electricity, what is necessary is just a thing of a kind which carries out subraw [of the water (steam)], and, specifically, they are a polymer electrolyte fuel cell, a phosphoric acid fuel cell, etc.

[0023]For example, in a polymer electrolyte fuel cell and a phosphoric acid fuel cell, as (1) - (3) type mentioned above, fuel gas from the reforming section 32 etc. mentioned later is first sent into the anode side, and a hydrogen ion is generated (H_2-> $2H^+$+$2e^-$). On the other hand, in the cathode side, air is supplied, oxygen ion is generated from oxygen in this air, and electric power occurs within a fuel cell. In a cathode, subraw [of the water] is carried out from said hydrogen ion and oxygen ion simultaneously with this (O_2+$2H^+$+$2e^-$ ->H_2O). (1/2) Most of

these water absorbs heat generated within a fuel cell, and it is generated as steam. An end of the connecting pipe 36 is connected to the cathode side of a fuel cell so that steam generated by this cathode side can be sent into the reforming section 32. On the other hand, the anode side is equipped with the purifying part 37 which purifies and discards nitrogen gas in unreacted hydrogen and the air, etc.

[0024]The reforming section 32 is connected to the other end of the connecting pipe 36 connected to the cathode side of the above-mentioned fuel cell 34, and the steam by which it is generated in the fuel cell 34, and the unreacted oxygen which remains are supplied to it. This reforming section 32 is equipped with the supply pipe 38 which supplies hydrocarbon raw materials, such as methane, and the inside is equipped with the catalyst for reforming required for reforming. The reforming section 32 reforms the hydrocarbon raw materials supplied by the internal catalyst to fuel gas by the steam reforming method and the partial-oxidation-reforming method. It is not necessary to necessarily use these reforming methods together, and they can also perform reforming only by one side. However, since steam and oxygen are supplied from the fuel cell 34, it is preferred to use together steam reforming and partial oxidation reforming, and to aim at effective use of water or oxygen.

[0025]When using together the steam reforming method and the partial-oxidation-reforming method, it is preferred to adjust these rates appropriately. For example, this regulation can be performed on the basis of considering it as a suitable temperature for a reaction. That is, although both steam reforming and partial oxidation reforming have a suitable reforming temperature, at the time of reforming, the temperature of a reforming section is changed with heat of reaction etc. Especially steam reforming is an endothermic reaction, and since partial oxidation reforming is an exothermic reaction, it can maintain suitable fixed reaction temperature by adjusting the balance of these endothermic reactions and an exothermic reaction.

[0026]In order to adjust the balance of such a reforming method, a connecting pipe can be equipped with the control part 40 which controls the quantity which sends steam or oxygen into the reforming section 32, and the reforming reaction of the hydrocarbon raw materials in a reforming section can also be controlled. This control part 40 may be what restricts gaseous passage by opening of a valve etc., and an ejecting means which discharges steam and oxygen from the connecting pipe 36 in part, for example. In the case of what controls only steam, this control part 40 may restrict the quantity of the steam which adjusts the temperature in the connecting pipe 36 and flows into the reforming section 32 by using some steam as water.

[0027]Although the above-mentioned control part 40 has played the role which mainly adjusts both the amounts of oxygen and water vapor contents that pass along a connecting pipe, and controls both the amount of supply to the reforming section 32, it is good to prepare the oxygen

utilization factor controller 42 for the case where he would like to adjust only the amount of oxygen supply supplied to a reforming section at a fuel cell. This oxygen utilization factor controller 42 will adjust the unreacted amount of oxygen, if the oxygen utilization factor in the fuel cell 34 is adjusted and put in another way, and it adjusts the amount of oxygen sent into the reforming section 32. Thus, by adjusting the amount of oxygen supply to the reforming section 32, the rate of the partial oxidation reforming in the reforming section 32 is adjusted, for example, it can adjust reducing the temperature of a reforming section etc.
[0028]In this controller 42, the following method etc. are mentioned as a method of adjusting the amount of oxygen.
[0029]The first method is a method of changing the air capacity sent into the fuel-cell-cathode side from the conduit 35a. For example, in this case, when the amount of production-of-electricity fixed jam consumption oxygen in a fuel cell is constant, it becomes an effective method. Since the air capacity changes even when the amount of consumption oxygen is constant, an oxygen utilization factor and the amount of unconsumed oxygen can be changed.
[0030]The second method is a method of changing the production of electricity of the direct fuel cell 34. Conversely, if a production of electricity changes in the situation where sending of air is constant, the amount of consumption oxygen in the fuel cell 34 can be changed. A production of electricity is controllable by the signal from an inverter etc.
[0031]On the other hand, the connecting pipe 36 is equipped with the steam generation part 44 corresponding to the case where he would like to adjust the steam reforming in the reforming section 32. A part is water which has not been evaporated although many of water generated in the cathode of the fuel cell 34 is steam. Although the water produced here can be sent into the sifting section 33 mentioned later, and is applicable to CO conversion reaction or can also be used as cooling service water of CO selective oxidation part 35, heating evaporation may be carried out by the steam generation part 44 if needed, and it may also be sent into the reforming section 32 as steam. As a case where it is required here, the time of starting of the fuel cell 34, etc. are mentioned, for example. That is, since a required quantity of steam is not obtained from the fuel cell 34 at the time of starting of the fuel cell 34, temporarily, in the steam generation part 44, heating evaporation of the water currently stored beforehand can be carried out, and the generated steam can be supplied to the reforming section 32.
[0032]Unreacted hydrogen of an anode, etc. can be used as fuel of this steam generation part 44. When hydrogen is used, hydrogen is burned (oxidization) and the heat of reaction in that case can be used as heating energy of steam generation.
[0033]The sifting section 33 is connected to said reforming section 32. This sifting section 33 makes CO in the fuel gas generated in the reforming section 32 react to water, and conversion is carried out to CO_2. Specifically, the conversion reaction of this sifting section 33 is the reaction of (6) types mentioned above, i.e., $CO+H_2O\text{->}H_2+CO_2$. Although water required for a

reaction is not illustrated to the conversion in this sifting section, the water generated by the cathode side of the fuel cell 34 as mentioned above can be used. Since water is discharged also from the anode side, these water may be collected and the sifting section 33 may be supplied. When supplying the water discharged from the these anode and cathode side to a sifting section, the amount of supply may be controlled based on the temperature of the reformer 32, for example, sifting section 33 grade.

[0034]CO selective oxidation part 35 is connected to the sifting section 33. This CO selective oxidation part 35 oxidizes, and carries out conversion of CO which was not removed in the sifting section 33 to CO_2. The conversion reaction ($CO+1/2O_2$->CO_2) of this CO selective oxidation part 35 requires oxygen. Therefore, the conduit 35a which sends in air as an oxygen source is formed in CO selective oxidation part 35. Since the conversion reaction in this CO selective oxidation part 35 is a reaction which burns CO, it is accompanied by generation of heat. In order to remove this generation of heat, it is preferred in this CO selective oxidation part 35 to have a cooling method, for example, the composition which blows the water generated by the anode [of the fuel cell 34] and cathode side as mentioned above as this cooling method may be adopted as it. The quantity of the water blown here may be controlled based on temperature, such as the reformer 32 35, for example, CO selective oxidation part etc.

[0035]Next, an operation of the fuel cell system constituted as above-mentioned is explained.

[0036]At the time of power generation of the fuel cell system 30, hydrocarbon raw materials are first sent into the reforming section 32 via the supply pipe 38. On the other hand, air is blown into the cathode side of a fuel cell, and oxygen required for partial oxidation reforming is sent into the reforming section 32 via the connecting pipe 36. If required, steam will be generated in the steam generation part 44, and this steam will be sent into the reforming section 32 through the terminal area 36. Thus, if hydrocarbon raw materials, and oxygen or steam is sent into the reforming section 32, in the reforming section 32, reforming will be performed for hydrocarbon raw materials by steam reforming and partial oxidation reforming, and fuel gas will be generated. Subsequently the fuel gas generated here passes the sifting section 33 and CO selective oxidation part 35. In this case, CO by which subraw was carried out at the time of reforming is removed.

[0037]The fuel gas with which CO was removed is sent into the anode of the fuel cell 34. On the other hand, since air is supplied, when fuel gas is sent in, operation of a fuel cell is started by the cathode. If operation of a fuel cell is started, electric power will occur in a fuel cell and subraw [of the steam] will be simultaneously carried out by the cathode side.

[0038]Via the connecting pipe 36, the steam by which subraw was carried out here is sent into the reforming section 32, and is used for the steam reforming of hydrocarbon raw materials. Intact oxygen is also sent into the reforming section 32 via the connecting pipe 36 by the fuel

cell 34, and it is used for the partial oxidation reforming of materials. Thus, as long as operation of a fuel cell is started and the operation is continued, subraw [of the steam] is carried out in a fuel cell. Steam and unreacted oxygen which carried out subraw here are sent into the reforming section 32 via the connecting pipe 36, and fuel gas continues being generated. When the balance of quantity, such as steam supplied from a fuel cell and oxygen, needs to be adjusted, it can adjust by the control part 40, the steam generation part 44, and the oxygen utilization factor controller 42, and oxygen of a suitable quantity for the reforming section 32 and steam can be supplied.

[0039]As above, by the reforming section 32, fuel gas required for operation of the fuel cell 34 is generated, and, on the other hand, steam required for the reforming section 32 is generated by the fuel cell 34, and unreacted oxygen remains. Therefore, by having a circulating route between the fuel cell 34 and the reforming section 32 like the connecting pipe 36, it becomes unnecessary to equip the reforming section 32 with an evaporator needed for steam reforming, and a miniaturization of a system can be attained conventionally.

[0040]Water other than steam discharged from the water [which is generated by the fuel cell 34], water [which is specifically discharged from the anode side], and cathode side is also collected, and effective use of water by which subraw is carried out can be aimed at by supplying the sifting section 33 and CO selective oxidation part 35.

[0041]Fuel gas is generated to below by using 1 mol of methane as materials, and an example at the time of making a fuel cell operate is explained to it.

[0042]If 1 mol of methane is supplied to the reforming section 32 as hydrocarbon raw materials, about 2.3-mol fuel gas (hydrogen) will be generated via the reforming section 32, the sifting section 33, and CO selective oxidation part 35, and this fuel gas will be supplied to an anode of the fuel cell 34. On the other hand, air is sent into a cathode of the fuel cell 34 so that about 1.33-mol oxygen can be supplied. In the fuel cell 34, power generation is performed using these ****** rare ********** and air. In the case of this power generation, with an anode, fuel gas is used about 80%, and on the other hand, with a cathode, when about 68% of oxygen is used, subraw [of the water (most is steam) which is about 1.8 mol] is carried out. Steam by which subraw was carried out here, and unreacted oxygen (0.425 mol) are sent into the reforming section 32 via the connecting pipe 36, and reforming of 1 mol of methane is performed by these steam and oxygen. Thus, water by which it is generated within a fuel cell, thermal energy, and unreacted oxygen can be used effectively via a connecting pipe by returning subunboiled-water steam and unreacted oxygen to a reforming section.

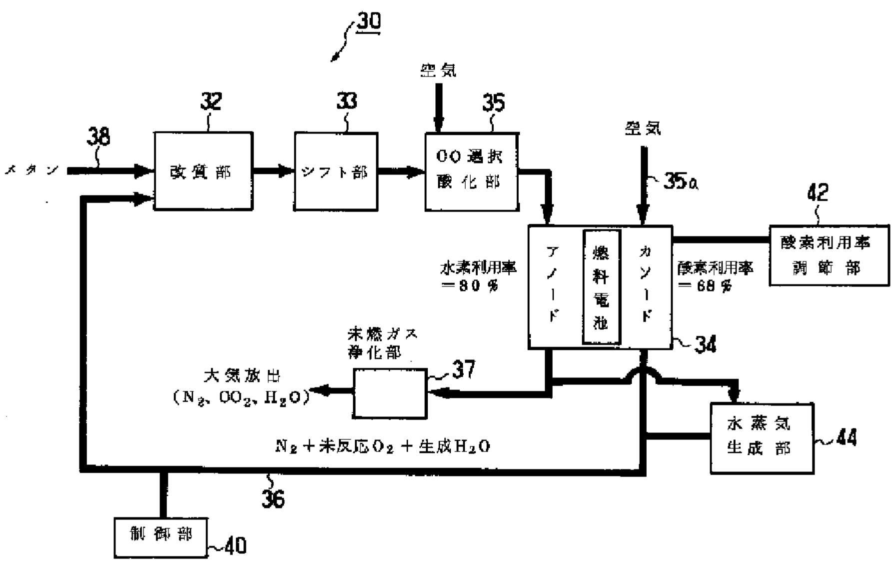
[0043]

[Effect of the Invention]Since according to [above passage] this invention the steam generated by a fuel cell and the unreacted oxygen which remains are sent into a reforming section and used for reforming of materials, it becomes possible for it to become unnecessary

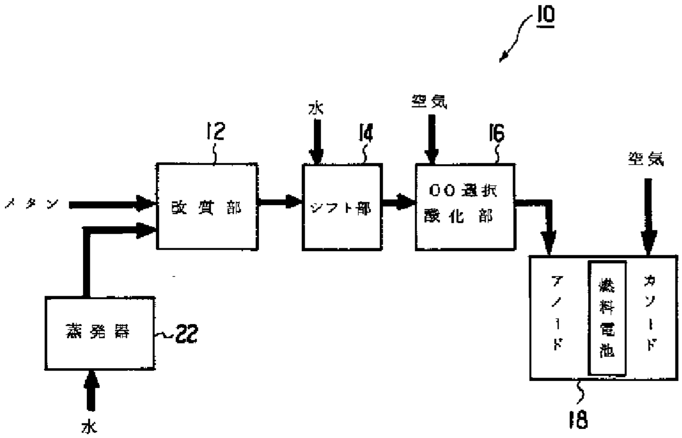
to install conventionally the evaporator etc. which were needed for the reforming section, and to attain the miniaturization of a system. It becomes possible by returning steam and oxygen of a such fuel cell to a reforming section to use effectively water, thermal energy, etc. which are generated by a fuel cell.

[Brief Description of the Drawings]
[Drawing 1]It is a figure showing the entire configuration of the fuel cell system of this embodiment.
[Drawing 2]It is a figure showing the entire configuration of the conventional fuel cell system.
[Explanations of letters or numerals]
30 A fuel cell system and 32 [A control part, 42 oxygen-utilization-factor controller, and 44 / Steam generation part.] A reforming section and 34 A fuel cell and 36 A connecting pipe and 40

[Drawing 1]



[Drawing 2]



[Translation done.]